

[54] **COOLING SYSTEMS FOR INTERNAL COMBUSTION ENGINES**

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[51] Int. Cl. **F01p 1/10**

[58] Field of Search **123/41.32, 41.42, 123/41.57**

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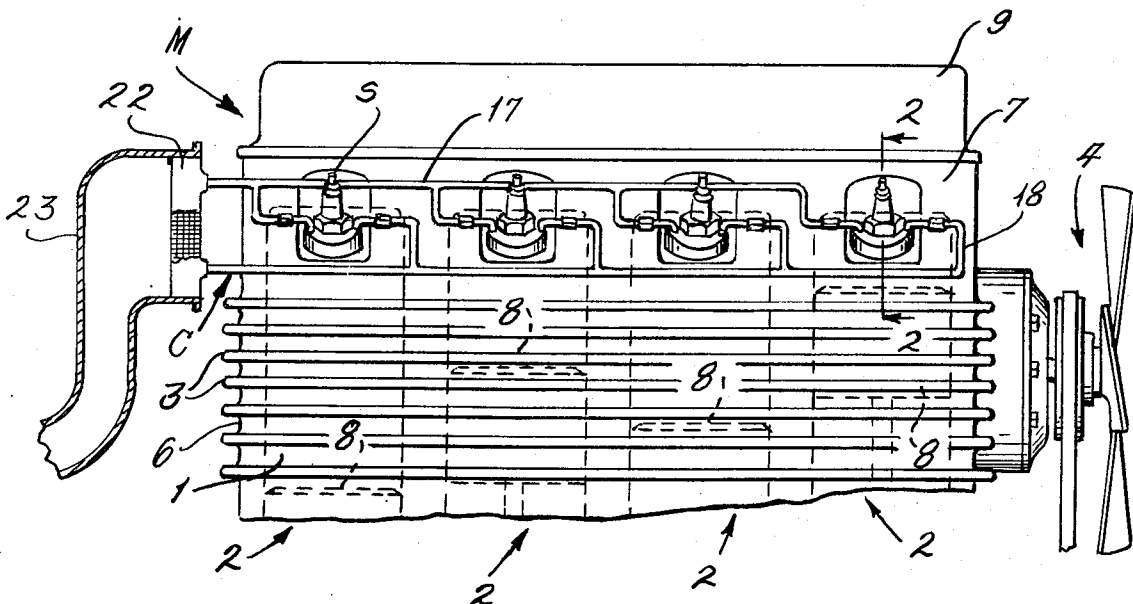
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[57] **ABSTRACT**

A cooling system which comprises one or more cool-

ing jackets secured to or otherwise formed with the head plate of an internal combustion engine and in close proximity to the cylinder heads of the engine. Each jacket is closely adjacent to and surrounds a spark plug associated with a cylinder. Furthermore, each of the jackets is connected to a heat exchanger, such as a radiator, through coolant delivery and return lines. A metal composition which is in a solid state at non-operating temperatures of the engine and is changed to a liquified state by the heat of the engine, when operating, serves as the coolant, and during operation is continually circulated through the jackets surrounding each of the spark plugs to cool the portions of the engine adjacent thereto. By virtue of cooling the immediate areas of the engine in proximity to the spark plugs, the heat of combustion can be rapidly dissipated which allows the engine to be operated at optimum temperatures, thereby increasing the operating efficiency, without the attendant problems incident to the presence of localized excess temperature conditions normally produced at or adjacent to the cylinder heads. Moreover, as a result of higher operating efficiency, the exhaust gases from engines equipped with the present cooling system contain a relatively low amount of the pollutants normally produced by internal combustion engines.

20 Claims, 4 Drawing Figures



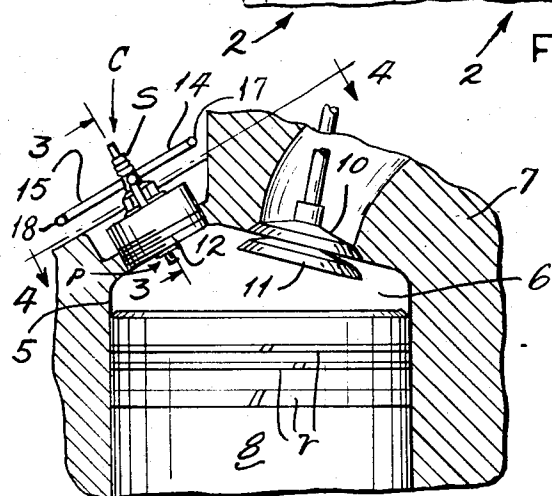
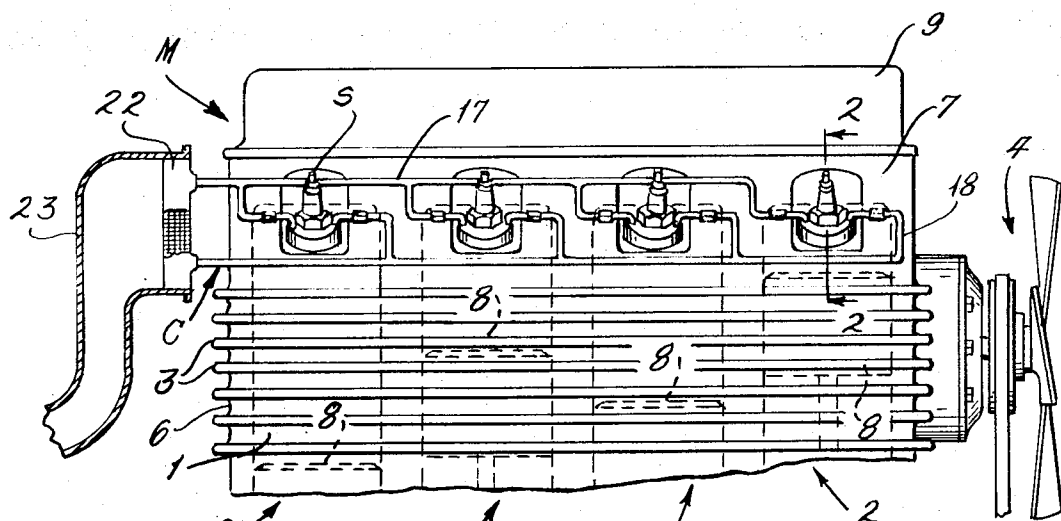


FIG. 2

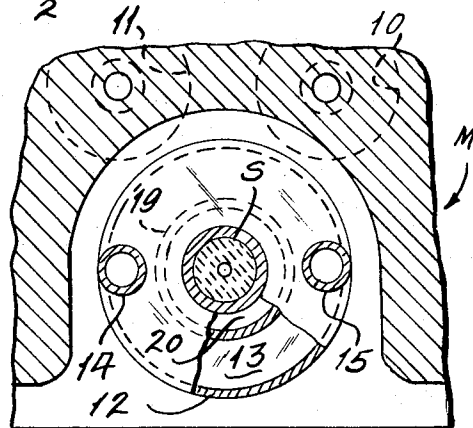


FIG. 4

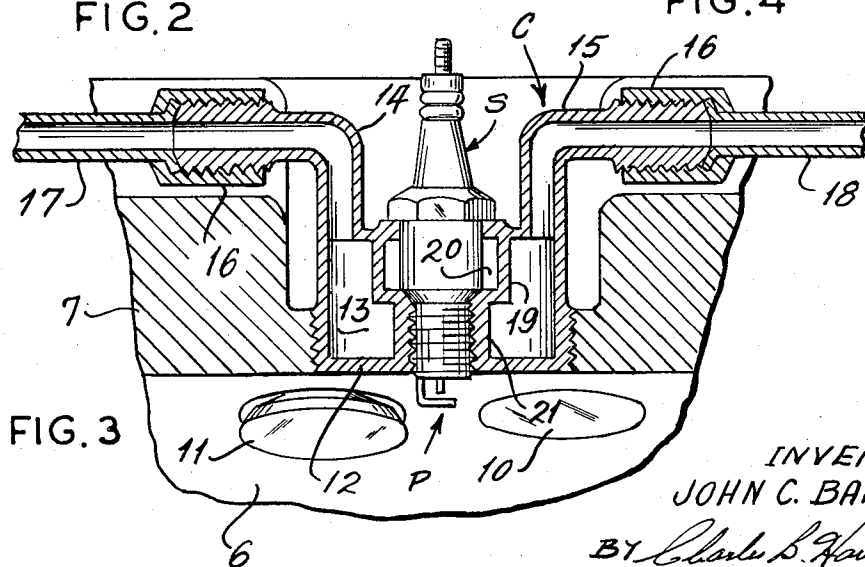


FIG. 3

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COOLING SYSTEMS FOR INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

This invention relates in general to certain new and useful improvements in cooling systems for internal combustion engines, and more particularly, to a cooling system which is designed to reduce localized heat which otherwise would be present particularly in the regions around the cylinder heads of an internal combustion engine.

Most internal combustion engines presently used in automotive vehicles and elsewhere are either air-cooled or liquid-cooled. The larger bore engines by virtue of their size and relatively high compression ratios, are generally liquid-cooled and employ water or a mixture of water and a high-boiling alcohol, such as ethylene glycol, as the cooling medium. The smaller size engines are generally air-cooled and usually include a blower which is designed to direct a stream of air around and against the engine block. The blower is normally operated by the crankshaft of the engine.

The liquid-cooled, gasoline powered engine is designed to operate at temperatures in the range from 120° F to 180° F, and the air-cooled gasoline powered engine is designed to operate at temperatures normally higher than 200° F. The temperature at the cylinder heads of these engines often exceeds 500° F, and the temperature at the spark plug gap in each of these engines may substantially exceed 500° F, extending even to a range of several thousand degrees fahrenheit and higher.

In a liquid-cooled engine, the problems created by localized high temperature conditions are abated somewhat by virtue of the liquid coolant that rapidly circulates through jackets around the cylinder walls. In some cases, the head plate of the liquid-cooled engine is liquid-cooled, while in other cases the only temperature reduction of the head plate is achieved by airflow and by heat conductivity through the engine block. The head plate temperature in an air-cooled engine however, is usually not reduced as efficiently as the head plate temperature in a liquid-cooled engine, a major portion of heat dissipation from the head plate occurring as a result of air flow over the engine head. Although some heat reduction occurs during the intake and exhaust cycles in a four cycle air-cooled engine, the high temperatures which are present at the head of the cylinder often create other problems in an air-cooled engine, such as early valve fatigue, valve warpage, and the like, all of which have an adverse effect on engine efficiency and engine life. In addition, the temperature gradient across the length of the cylinder may be quite substantial, especially in an air-cooled engine, thereby further reducing the overall operating efficiency of the engine. These and other undesirable conditions are overcome by the improved engine cooling system of the present invention.

It is therefore the primary object of the present invention to provide an improved cooling system for internal combustion engines which reduces localized temperature excesses created at or near the engine cylinder heads.

It is another object of the present invention to provide a cooling system of the type stated that preferably employs a metal or metal containing coolant which is normally solid at ambient temperatures when the en-

gine is not operating but changes to a free flowing liquid when subjected to the heat generated by operation of the engine.

It is a further object of the present invention to provide a cooling system of the type stated which provides relatively small temperature differential gradients across the lengths of the cylinder walls of an internal combustion engine thereby increasing the overall operating efficiency of the engine.

It is an additional object of the present invention to provide a cooling system of the type stated which can be manufactured at relatively low cost and which is highly efficient in operation.

It is also an object of the present invention to teach the use of a liquified metallic coolant for circulating through the cooling system of an engine where it is desired to provide efficient means to carry away and dissipate heat that may be present.

It is yet another object of the present invention to teach the use of a coolant that has both electrical conducting and heat conducting properties.

These and other objects and advantages of the present invention will become apparent after considering the following detailed specifications which covers preferred embodiments of the subject system in conjunction with the accompanying drawing wherein:

FIG. 1 is a view of an air-cooled internal combustion engine which is provided with the cooling system of the present invention;

FIG. 2 is a fragmentary vertical sectional view taken along line 2—2 of FIG. 1 showing a portion of a cylinder in the internal combustion engine;

FIG. 3 is a fragmentary section view taken along line 3—3 of FIG. 2 and functionally illustrating the portion of a cooling jacket of the present system that surrounds a spark plug located in an engine cylinder head; and

FIG. 4 is a fragmentary horizontal sectional view taken along line 4—4 of FIG. 2.

GENERAL DESCRIPTION

Generally speaking, the present invention resides in a novel cooling system for use with internal combustion engines where a metallic type coolant, which has both electrical conducting properties and heat conducting properties is employed to carry away and dissipate the heat generated by the engine, and particularly the heat generated by and near the spark plugs. One embodiment of the present invention discloses a chamber forming member, such as a jacket, located extending around a spark plug at the cylinder head of an internal combustion engine. A coolant fluid inlet and a coolant fluid outlet are connected to this chamber forming member and to a radiator or other suitable heat exchanger which forms part of the cooling system. A metal or metal containing coolant can remove the heat generated at the head of the cylinder and the heat that is generated at or adjacent to the spark plug gap.

The coolant employed is generally a metal, a metal alloy, a metal solution, a metal compound, or mixtures thereof in a form that is solid at the ambient temperatures of a non-operating engine. The coolant and/or its ingredients are also melted by the heat of the engine, when operating so that circulation thereof through the chamber forming member and the radiator is enabled. Obviously, the subject system can and usually will be constructed to dissipate heat at all of the spark plugs and at other hot spots as well, if desired.

It is also contemplated to use coolants other than metal or metal containing coolants in the present invention. Such other coolants should, however, be relatively viscous or solid and non flowing at normal temperatures but easily liquified and made flowable at normal engine operating temperatures. Examples of non metal containing coolant substances include waxes such as parafin, and these may or may not contain particles or mixtures of other substances as desired.

The present invention can also be used with liquid-cooled internal combustion engines although some additional modification of the engine may be necessary to prevent overloading the present means by the overall needs of the liquid-cooling system itself. This can be accomplished by making the present hot spot cooling system independent of the main cooling system.

DETAILED DESCRIPTION

Referring now in more detail and by reference characters to the drawings which illustrate practical embodiments of the present invention, M designates a conventional air-cooled internal combustion engine having a block 1 which is shown divided into four or more aligned cylinder sections 2, in the manner as illustrated in FIG. 1. The block 1 is provided with a series of horizontally extending fins 3 which assist in air-cooling of the block 1. In this connection, a conventional blower 4, which may be operated from a crankshaft (not shown) in the engine M, is also provided for generating an airflow around the block 1.

By reference to FIG. 2, it can be seen that each cylinder section 2 contains a cylinder wall 5 forming a combustion chamber 6. A cylinder head 7 may be integrally formed with the cylinder wall 5 as illustrated, or secured thereto by means of head bolts (not shown) in any conventional manner. A piston 8 is movable within the cylinder wall 5 and may be conventionally provided with piston rings *r*. The piston 8 is normally connected to the crankshaft of the engine M by means of a connecting rod in the usual manner (also not shown). A valve cover 9 is removably secured to the engine block 1 for housing an intake valve 10 and an exhaust valve 11 associated with each cylinder section 2.

The present invention provides a cooling system C which generally includes a cooling jacket 12 threadably secured within an aperture formed in the upper end of the cylinder head 7, in the manner as illustrated in FIG. 2. The cooling jacket 12 is provided with a coolant chamber 13 and a coolant, of the type hereinafter described, is circulated through the chamber 13 through an inlet duct 14 and an outlet duct 15. The ducts 14 and 15 are provided with sleeve type fittings 16 for connection respectively to a coolant delivery tube 17 and a coolant return tube 18. The jacket 12 also internally includes an integrally formed annular wall 19 which provides an internal chamber 20 to accommodate a conventional spark plug S. It can be seen that the spark plug S is also removably threaded within a hub 21 integrally formed with the lower end of the annular wall 19, and is also insulated from the coolant which is contained in the coolant chamber 13. By further reference to FIG. 3, it can be observed that the spark plug S is provided with contacts P, which extend into the chamber 6 and are located closely adjacent to the interior surface of the cylinder head 7.

The coolant delivery tube 17 and the coolant return tube 18 are connected to a radiator 22, which may be

conventional in its construction, or to some other form of heat exchanger. The radiator 22 normally will be provided with cooling tubes and finned air-receiving ducts surrounding the tubes so that the coolant which is introduced into the radiator 22 through the coolant return tube 18 may be cooled for recycling through the various jackets 12. Furthermore, the blower or fan 4, will provide a sufficient flow of air through the radiator 22 in order to achieve the necessary temperature reduction of the coolant. A shroud or metal duct 23 may also be connected to the radiator 22 for removing heat from the radiator 22 and directing the same to an internal heater blower (not shown), which may be located in the vehicle housing the engine M in order to provide a supply of heated air for the passenger compartment of the vehicle.

The present cooling system can be used with series as well as with parallel connected coolant chambers associated with the various spark plugs and the engine hot spots to be cooled. One of the advantages obtained particularly when this system is used with parallel connected coolant chambers is that this type of engine construction makes it possible to locate the engine cylinders and associated parts relatively close together in the engine. This saves space and engine materials and enables the engine to be constructed to be more compact. This also reduces the amount of engine material that needs to be cooled. This advantage is obtained regardless of the number of engine cylinders.

The coolant selected for use in the present invention is preferably a metal, a metal alloy, a metal solution, a metal compound or mixtures of these, which coolant preferably has the desired property of being solid at ambient temperatures which are the non-operating temperatures of the engine M, and which coolant is capable of being heated to the molten or liquid state by the heat generated by the engine when the engine M is operating. In the molten or liquid state, the coolant should be relatively non-viscous to possess good fluid flow properties. The coolant preferably also possesses relatively good electrical conductivity properties as well. It has been found that certain metal containing coolants, including those mentioned, have the desired heat conductivity properties and also have good electrical conductivity properties and are highly effective for use in the present invention.

As stated previously, the normal operating temperature of most gasoline powered, liquid-cooled internal combustion engines is generally greater than 120° F and the operating temperature of most gasoline powered air-cooled internal combustion engines often exceeds 200° F. For this reason, the coolant selected for use with the cooling system of the present invention, will depend to some extent on the type of internal combustion engine, including the normal operating temperatures thereof. For liquid-cooled engines, the selected coolant preferably should have a melting point temperature of no greater than about 120° and 140° F, and for air-cooled engines, the coolant preferably should have a melting point temperature of no greater than about 200° F. For diesel engines, the coolant may have a substantially higher melting point temperature.

Some of the coolants which have been found to be suitable for use with the present cooling system include a number of commercially available alloys, such as the various so-called "soft solders," including, without limitation, the tin-zinc alloys, some of the bismuth alloys

including those sold under the commercial names of "woods metal" and "Lipourtz alloy," various tin-cadmium alloys, and tin-lead alloys, and other similar materials. Certain of the metal salts are also suitable as a coolant including zinc nitrate, zinc selenate, selenium tetrabromide, lead fluorosilicate, lead hydride, tin chloride-hydrate, tin chloride, and so forth. Various metals and metal containing substances such as gallium and gallium containing substances can also be used as the coolant. It is also possible to use other metals alone or as ingredients of substances which have even better electrical conductivity properties than the above but which are not solid or as solid at the non-operating conditions of the engine. Mercury, for example, will serve as an effective coolant. It has been found that coolants of the type described are highly effective in rendering the desired heat and/or electrical transfer properties.

Metal particles which have a melting point temperature somewhat higher than the melting point temperature of the coolant may be added to the coolant as an additional heat transfer medium. Such metal particles generally have a melting point temperature that is higher than the normal operating temperature of the engine and higher than the temperature achieved at the cylinder head 7. Accordingly, the metal particles when used may always remain in their solid state, but will be carried by the coolant when it is liquified and circulated. The size of metal particles when used should be sufficiently small so they will not interfere with normal fluid flow. Iron filings, nickel filings, platinum filings, and other like filings are typical of those that may be used for this purpose.

While metal-type coolants are preferred, due to their relatively good heat and electrical conductivity characteristics in some cases as indicated above it may be desirable and use certain non-metal coolants such as certain wax or wax-like substances, or other materials which are solid or relatively solid at non-operating temperatures of an engine but which will melt and liquify when subjected to the heat generated during operation of the engine. For example, certain aliphatic hydrocarbon waxes including the paraffinic hydrocarbons and other similar naturally occurring animal and vegetable waxes as well as the synthetic waxes, may be used as coolants. In addition, those metal particles which may be added to the metal-type coolants may also be added to and carried by the non-metal coolants to increase the overall heat conductivity thereof.

The coolant is selected with the desired melting point properties so that it will become molten or liquid when subjected to the heat generated by the engine M, when the latter is operating.

The coolant selected is preferably one which has a fairly high heat conductivity coefficient enabling fairly quick melting and liquification so that it will start circulating and cooling as soon as possible after the engine is started. This also enables relatively rapid engine warm up without damaging the engine which is an advantage. When the liquid coolant is circulating through each of the cooling jackets 12, the temperature of the coolant will have risen to a temperature substantially higher than its melting point temperature and will continue to circulate as long as the engine is on. During this time, the coolant will also be recirculated through the radiator 22 and the temperature reduced so that its temperature in the delivery tube 17 will be somewhat less than its temperature in the return tube 18. Never-

theless, the temperature of all of the coolant in the system will always remain above its melting point temperature during the operation of the engine M. However, when the engine is turned off and not operating, the coolant may solidify and no longer be able to circulate. Thereafter, when the engine is restarted and combustion again takes place in the various cylinders, the engine temperature will rapidly rise and reach its normal operating temperature level and hence, the coolant will again melt and be circulated in the system as described.

The convective current fluid flow resulting from the temperature differential between the coolant returned to the radiator 22 and the coolant which is being recirculated to the cooling jackets 12 from the radiator 22 will be generally sufficient for the purposes intended, thereby avoiding the necessity of a pump. Convective current fluid flow principles have been recognized and are effective in many fluid flow systems and may also be effective for the present cooling system. However, in some cases including larger engines where a large liquid flow volume is required, some form of pump could be employed.

Referring again to FIG. 1, the various components which form the present cooling system are shown located either adjacent to, or in close proximity to the engine block 1. For example, the radiator 22, which may be mounted on any supporting structure such as the engine block 1, is shown abutted against the engine block 1, and the system fluid connections are shown against or very near to the block 1. When the engine is not operating, and is at or close to ambient temperature, the coolant loses its latent heat of liquification and may thicken or even solidify. Thereafter, when the engine is again operated, the coolant will initially still exist in its thick or solid state and this condition will persist until the engine is heated sufficiently to liquify the coolant so that it can circulate. Inasmuch as all or most of the components of the cooling system are either in contact with, or are very closely spaced to the engine block 1, as explained, the coolant in the cooling system will more or less simultaneously liquify, thereby usually avoiding the necessity of auxiliary initial heating equipment. This will take place relatively rapidly due to the rapid manner in which the engine will generate heat particularly near the areas where the spark plugs are located and combustion takes place.

If the radiator 22 were located to be spaced from the engine block, then it might also be necessary or desirable to provide auxiliary heating means to heat and liquify the coolant contained therein and in the delivery and return tubes 17 and 18 associated therewith. The important thing is that as much of the coolant be liquified as rapidly as possible so that circulation will commence and normal engine cooling will take place. If there is a lag between the time the engine starts and the time that the coolant begins to circulate, no harm will result since the engine will still be normally lubricated and overheating usually has to occur for a prolonged period to cause damage. Also, during start up, the relatively low initial engine temperatures provide a greater heat sink reservoir for absorbing and dissipating excessive engine heat further reducing the possibility of heat damage during the time necessary for the coolant to liquify. However, because the preferred form of coolant has good electrical, as well as heat conductivity characteristics, once it is liquified and circulating its ability to conduct heat and cool the engine will be

much better than for any other known coolant. This means that the engine heat will more rapidly be conducted into the coolant and it also means that the heat carried by the coolant will more rapidly be conducted to the heat exchanger or radiator thereby substantially increasing the efficiency of the subject cooling system. Inasmuch as the coolant after liquifying is continually circulating when the engine M is operating, it will be able to substantially reduce the engine temperature particularly in those areas of the engine where the temperature is most likely otherwise to become excessively high.

As stated, the temperature at or near the cylinder heads 7 may exceed 500° F and such high temperatures are often damaging to the engine and may shorten engine life and they may cause undesirable operating problems. By using cooling systems and a coolant of the type described herein, it has been discovered that the temperature at the cylinder heads 7 can be substantially reduced with the beneficial results of efficiency maintained.

For multiple cylinder engines, it may be desired to use parallel coolant flow connections, although series connections are clearly also contemplated. In the event of parallel operation, it may be necessary to provide separate delivery tubes 17 and return tubes 18 connected to each of the cooling jackets 12 so that the coolant from one cooling jacket 12 is not delivered to and circulated in the next succeeding cooling jacket 12.

The present invention also contemplates the employment of a cooling jacket which is integrally formed in the block during the manufacture thereof, and the cooling jacket 12 would not then be threadedly connected to the cylinder head 7. Instead, the cooling jacket would be cast into the block, and fittings would be connected to the cooling jacket, which fittings would then be connected to the delivery tubes 17 and the return tubes 18. Fluid ducts could also be formed into the block to serve as parts of the delivery and return tubes.

As a result of the improved performance and higher operating efficiencies achieved from engines equipped with the subject improved cooling systems, undesirable waste products such as pollutants are substantially reduced. This includes pollutants such as carbon monoxide, and various hydrocarbon gases and particulates which result from insufficient oxidation of the volatile substances during combustion of the hydrocarbon fuel. The various nitrogenous oxides which are found in the exhaust gases of an internal combustion engine also result largely from an insufficient reducing atmosphere in the engine. By operating the engine with a higher overall efficiency, the oxidizable constituents in the engine fuel are oxidized more efficiently and the reducible constituents are reduced more efficiently, thereby substantially reducing the amounts of pollutants contained in the exhaust gases. Hence, the present cooling systems not only increases the operating efficiency and reduces the exhaust of undesirable waste products but it also in the process makes for more efficient combustion of the fuel and a smoother flow of the power.

Thus, there has been shown and described a novel system for use in cooling engines including air-cooled and liquid-cooled internal combustion engines, which system preferably employs a metal or metal containing coolant which has relatively good electrical as well as heat conducting properties to increase the cooling effi-

ciency by increasing the rate at which the heat generated by the engine is carried away and dissipated. The coolant employed in the present invention preferably contains some metal, metal alloy, metal solution, or a metal compound or mixtures of a combination of the aforesaid, which coolant may become thick and viscous or even solid or partially solid at non-operating temperatures of the engine but melts and becomes fluid when subjected to the heat generated by the engine, when operating, so that easy circulation of the coolant in its liquid state is made possible. It will be apparent to those skilled in the art, however, that many changes, modifications, variations and other uses and applications of the present system and of the coolant circulated therein are possible, and all such changes modifications, variations and other uses and applications which do not depart from the spirit and scope of the invention are deemed to be covered by the invention which is limited only by the claims which follow.

Having thus described my invention, what I desire to claim and secure by Letters Patent is:

1. A cooling system for hydrocarbon combustion engine which operates through gas ignition means and compression means; said cooling system comprising a jacket with a cooling chamber therein in close proximity to said ignition means, a cooling medium introduceable into said cooling chamber, at least a portion of said cooling medium becoming relatively solid at non-operating temperatures of said engine and said medium becoming liquidified when subjected to the heat generated by the engine during operation thereof, and circulation means including the cooling chamber through which the said liquified cooling medium can circulate to carry away some of the engine heat generated during operation.

2. The cooling system of claim 1 further characterized in that said cooling medium comprises a metal constituent.

3. The cooling system of claim 1 further characterized in that a heat exchanger is inclined in the said circulation means.

4. The cooling system of claim 1 further characterized in that said cooling system includes a housing attached to the engine, said cooling chamber being formed in said housing, an ignition element extending into said power chamber in close proximity to said cooling chamber.

5. In a hydrocarbon combustion engine having a compression chamber and means for igniting gas compressed therein, the improvement comprising a closed fluid circulating system including a jacket with a coolant chamber therein at least a portion of which is in close proximity to the gas igniting means, a cooling medium positioned in said circulating system for circulating therethrough including through the coolant chamber in the jacket when the engine is operating, said cooling medium being characterized by being relatively non-fluid at ambient temperatures, but becoming an easily flowing fluid when exposed to the normal operating temperatures of the engine for circulating in the system.

6. In the engine defined in claim 5, the cooling medium includes a substance that liquifies at temperatures greater than about 120° F.

7. In the engine defined in claim 7, the cooling medium contains at least some metal containing substance.

8. In the engine defined in claim 7, further characterized in that the metal containing substance is a relatively good electrical conductor.

9. In the engine defined in claim 8, further characterized in that the metal containing substance liquifies when subject to a temperature in a range from approximately 120° to approximately 450° F.

10. In the engine defined in claim 7 further characterized in that the metal containing substance is selected from the class consisting of metals, metal alloys, metal solutions, metal compounds, and mixtures of the foregoing.

11. In the engine defined in claim 7 further characterized in that the cooling medium contains a wax-like material.

12. A cooling system for an internal combustion engine that includes a power cylinder with a piston movably positioned therein, means for introducing a combustible gas into the power cylinder, means for igniting the gas to move the piston on a power stroke and means to exhaust the waste products of combustion, comprising jacket means enclosing a chamber in close heat transfer proximity to the gas ignition means and to the power cylinder, means communicating said chamber with heat exchanger means, and a coolant substance positioned in said chamber and in the means communicating said chamber with the heat exchanger means, said coolant substance being characterized by being relatively thick and non-fluid at ambient non-operating conditions of the engine becoming highly fluid for circulation between the chamber and the heat exchanger means when subjected to the temperatures generated by the engine when operating.

13. The cooling system defined in claim 12 wherein the coolant substance contains an ingredient that has relatively good electrical and thermal conductivity characteristics.

14. In a hydrocarbon combustion engine having a compression chamber for compressing a combustible gas and an ignition element extending into said compression chamber; a first cooling jacket in close proximity to a portion of said chamber and containing a coolant which is generally in a liquid condition at non-operating temperatures of the engine, a second cooling

jacket at least a portion of which is in close proximity to the gas ignition means, said second cooling jacket being located in heat exchange relationship to said first cooling jacket and to the compression chamber, said second cooling jacket containing a cooling medium which is in a relatively non-flowable condition at non-operating temperatures of the engine but liquifies and becomes more flowable when subjected to heat generated in the compression chamber during operation of the engine.

15. The hydrocarbon combustion engine of claim 14 further characterized in that the coolant in the second jacket includes a metal containing component.

16. The hydrocarbon combustion engine of claim 14 further characterized in that the coolant in the second jacket includes a metal containing component which has relatively good electrical conductive characteristics.

17. The hydrocarbon combustion engine of claim 14 further characterized in that the first and second jackets have a common wall separating them, said common wall being constructed to provide good heat transfer characteristics between the liquid coolant in the first jacket and the cooling medium in the second jacket.

18. The method of cooling a hydrocarbon combustion engine which includes a power chamber therein and ignition means associated therewith for igniting fuel introduced thereto, said method comprising circulating a cooling medium in close proximity to said ignition means so that the medium is exposed to the temperatures generated thereby, said cooling medium being in a relatively solid non-flowing condition at non-operating temperatures of said engine and said medium being liquified by the heat generated in the power chamber of the engine during operation of the engine.

19. The method of cooling a hydrocarbon combustion engine of claim 18 further characterized in that said cooling medium contains a metal constituent.

20. The method of cooling a hydrocarbon combustion engine of claim 18 further characterized in that the metal constituent of the cooling medium liquifies at temperatures greater than 120° F.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,765,384 Dated October 16, 1973

Inventor(s) John C. Barnard

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 64, "chambe" should be "chamber".

Column 5, line 36, "and" should be "to".

Column 5, line 55, "hat" should be "that".

Column 8, line 40, "inclined" should be "included".

Column 8, line 60, "th" should be "the".

Column 8, line 65, "7" should be "5".

Signed and sealed this 9th day of April 1974.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

G. MARSHALL DANN
Commissioner of Patents